

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problems Mailbox.**

THIS PAGE BLANK (USPTO)



Europäisches
Patentamt

European
Patent Office

PCT/99/05632

09/763287

Office européen
des brevets

EJU

EP99/5632

REC'D 20 SEP 1999

WIPO PCT

Bescheinigung Certificate

Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

98116318.1

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)

Der Präsident des Europäischen Patentamts:
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

Alette Fiedler

A. Fiedler

DEN HAAG, DEN
THE HAGUE,
LA HAYE, LE

09/09/99

THIS PAGE BLANK (USPTO)



Europäisches
Patentamt

European
Patent Office

Office européen
des brevets

Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.: 98116318.1
Demande n°:

Anmeldetag:
Date of filing: 28/08/98
Date de dépôt:

Anmelder:
Applicant(s):
Demandeur(s):
SIEMENS AKTIENGESELLSCHAFT
80333 München
GERMANY

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:

Receiver and method of recovering data from radio signals

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat:
State:
Pays:

Tag:
Date:
Date:

Aktenzeichen:
File no.
Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:

H04B1/707

Am Anmeldetag benannte Vertragsstaaten:
Contracting states designated at date of filing: AT/BE/CH/CY/DE/DK/ES/FI/FR/GB/GR/IE/IT/LI/LU/MC/NL/PT/SE
Etats contractants désignés lors du dépôt:

Bemerkungen:
Remarks:
Remarques:

THIS PAGE BLANK (USPTO)

GR 98 P 2423

EPO - Munich
35

28. Aug. 1998

1

Description of Invention:

Receiver and method of recovering data from radio signals

- 5 The present invention relates to receivers which operate to recover data for at least one of a plurality of users from contemporaneously detected like modulated radio signals. Furthermore the present invention relates to a method of recovering data for at least one of the plurality of users
- 10 from contemporaneously detected like modulated radio signals. More specifically the present invention relates to radio receivers for recovering data from radio signals modulated in accordance with code division multiple access.
- 15 Data is communicated using code division multiple access systems by combining the data with a user specific spreading code and conveying the combination using radio signals which are transmitted between a transmitter and a receiver. At the receiver, the data is recovered from the radio signals by
- 20 comparing the received radio signals with the user specific spreading code which is known to the receiver. In this way, a plurality of transmitters associated with a corresponding plurality of users may be arranged to contemporaneously communicate data from the transmitters to receivers which
- 25 detect the data by comparing the radio signals with the unique user specific spreading code associated with each of the users.
-
- 30 A result of combining the data with a user specific spreading code, is that a bandwidth of the resulting radio signals is greater than that which would be the case if the data were carried alone by the radio signals. As a result, the frequency bandwidth occupied by code division multiple access signals is greater than a coherence bandwidth of the radio
- 35 communications channel through which the signals pass. As a result code division multiple access signals are provided with an advantageous effect in that the signals themselves

GR 98 P 2423

2

exhibit frequency diversity in that parts of the signals are communicated in frequencies which suffer fading independently.

5 Code division multiple access is used in both second and is now being proposed for third generation mobile radio telephone systems. A characteristic of a frequency bandwidth in which radio signals are transmitted in second and third generation mobile radio telephone systems, is that the radio
10 signals arrive at receivers of the system via multiple paths. As a result, the received signals exhibit inter symbol interference which must be cancelled in order for the data to be recovered. A further advantage of code division multiple access, is that the increased bandwidth of the radio signals
15 allows for each of the paths via which the radio signals reach the receiver to be individually determined and the radio signal energy for each of the paths to be recovered and combined to facilitate detection of the communicated data. A receiver which operates to effect the detection of individual
20 paths via which radio signals reach the receiver is known to those skilled in the art as the rake receiver.

One known rake receiver which operates to combine conventional rake reception techniques with multi-user
25 detection is described in a published article entitled 'A multi-user receiver for code division multiple access communications over multipath channels', by U. Fawer and B. Aazhang published in IEEE Transactions on Communications, Vol. 43, No. 2/3/4, February/March/April 1995 at pages 1556 -
30 1565. This known receiver is provided with a plurality of data detectors known as rake fingers which together form a rake receiver. Each of the fingers of the rake receiver are assigned to one of the plurality of users and one of a plurality of temporal displacements corresponding to one of a
35 plurality of paths via which the radio signals reach the receiver. Furthermore the disclosed receiver is provided with a multi-user data detector which is fed with symbols detected

GR 98 P 2423

3

by each of the rake fingers and serves to effect an iterative process from which data from each of the individual users is recovered by treating the detected symbols as either wanted data which is therefore recovered by the iterative process or
5 interfering symbols which are arranged to be cancelled from the wanted data.

Rake receivers for code division multiple access radio signals suffer from multiple access interference, which is
10 generated from other unwanted radio signals and may be described for the detection of each symbol individually by a cross-correlation between radio signals for different users during one symbol period before a symbol estimate is generated by each of the rake fingers. Furthermore
15 interference is also caused in each of the rake fingers from radio signals reaching the receiver via other paths from the same user which have different temporal displacements which do not correspond with the temporal positions at which each rake finger is recovering the data from the radio signals. As
20 such, self inter symbol interference is caused which may be described for the detection of each symbol individually by the auto-correlation of the radio signals for a specific user with a time shift equal to the difference in the temporal displacement between that operated by the rake finger and
25 other interfering paths during one symbol period before the rake finger recovers an estimate of the symbol.

It is an object of the present invention to provide an improved rake receiver which is arranged to substantially
30 reduce the effects of self inter symbol interference and multiple access interference, to improve a probability of correctly estimating the data symbols.

The invention resides generally in a rake receiver having a
35 plurality of data detectors each of which is arranged to recover data symbols from radio signals at a particular temporal displacement and for a particular user specific code

GR 98 P 2423

4

and by dynamically assigning the data detectors between a plurality of temporal displacements and user specific codes independence upon a relative signal strength of the radio signals associated with each of the users.

5

According to the present invention there is provided a receiver for recovering data for at least one of a plurality of users from contemporaneously detected like modulated radio signals generated by the users from user data in combination with a plurality of user specific codes, the receiver comprising a plurality of data detector means each of which is operatively associated with one of the plurality of the user specific codes and one of a plurality temporal displacements with respect to an impulse response of a communications channel through which the radio signals have passed, each of the data detector means operating to estimate symbols of the data for one of the users from the received radio signals in combination with the user specific spreading code and the temporal displacement, a signal strength estimation means which operates to determine a relative strength of the received radio signals from which each of the user data symbols was estimated by the data detectors, and a receiver controller which operates to assign the user codes and the temporal displacements to each of the data detectors, wherein the receiver controller operates to re-assign the plurality of spreading codes and the temporal displacements to the data detectors consequent upon the relative strength of the radio signals, thereby facilitating recovery of data symbols for the at least one user.

30

Known rake receivers are arranged to the effect that a plurality of the data detectors are distributed equally amongst a plurality of users so that an equal number of data detectors are provided to each user. The data detectors assigned to each user are arranged to generate an estimate of a transmitted symbol from radio signals received at a particular temporal displacement. As a result of the fact

35

GR 98 P 2423

5

that radio signals from some users will be received with a substantially higher signal strength than radio signals received from other users, data symbols transmitted by users with strong signals will be more easily detected than symbols from users with relatively weaker radio signals. This situation is known to those skilled in the art as the 'near/far' problem. As such, users with weaker radio signals suffer most from multiple access interference and self inter symbol interference. However by determining the relative strengths of the received radio signals after a first estimate of the data symbols represented by the radio signals and subsequently reassigning the plurality of data detectors to the effect that users with weaker radio signals are arranged to be provided with a greater number of the data detectors, the radio receiver is arranged to provide an improvement in the probability of correctly estimating the data symbols from all users. The symbols estimated from users having stronger radio signals are in any case not disadvantaged by this reassignment since users with stronger signals do not suffer as greatly from inter symbol interference or multiple access interference from the weaker radio signals.

Advantageously the signal strength estimator means further operates to estimate the strength of components of the radio signals received at different temporal displacements, and the receiver controller further operates to reassign the plurality of data detectors in accordance with the relative strength of the signals.

Advantageously the radio receiver may further comprise a signal regenerator means coupled to the data detector means and arranged to regenerate received radio signals associated with at least one of the users by combining the estimated user data symbols with one of the plurality of user specific codes in dependence upon one of the temporal displacements.

GR 98 P 2423

6

The data detectors may further include means for subtracting the regenerated signals fed thereto from the received signals prior to the estimation of the user data symbols from a result of the subtraction.

5

By regenerating an estimate of the radio signals from particular users, and subtracting these radio signals from the received radio signals, the effect of stronger interfering signals may be cancelled from the radio signals from which data symbols from users with weaker radio signals may be subsequently estimated. As such, the assignment of the data detectors to the effect of generating an estimate of data symbols from users with relatively stronger signals is arranged to the effect that more of the data detectors are assigned to users with stronger radio signals. During a first iteration of the detection process, the data symbols from the stronger users are estimated and subsequently regenerated and subtracted from the received radio signals. Thereafter the plurality of data detectors are assigned to the weaker radio signals and the data symbols from these weaker users estimated from the result of subtracting the regenerated signals from the received radio signals. As such a different assignment strategy is exercised when the data detector includes a regenerator for subtracting the effect of users with stronger radio signals from the received signals.

The radio receiver may include a combiner means which operates to combine each of the estimates of the data symbols associated with a user to generate a composite data symbol decision. The combiner means may be a joint detector means which operates to cancel contemporaneously detected data symbols from the composite symbol decision to recover the data associated with one user.

The data detector means may be a rake finger and the users specific codes may be spreading codes the radio signals from

GR 98 P 2423

7

the plurality of users being generated in accordance with code division multiple access.

According to a further aspect of the present invention there is provided a method of recovering data for at least one of a plurality of users from contemporaneously detected like modulated radio signals generated from user data and a plurality of user specific codes, the method comprising the steps of processing the radio signals with a plurality of data detector means so as to estimate data symbols associated with a plurality of the users at a plurality of temporal displacements with respect to an impulse response of a communications channel through which the received signals have passed, determining a relative strength of the radio signals from which each of the user data symbols were estimated and re-assigning the user specific codes and temporal displacements to the plurality of data detectors for at least one of the users in dependence upon the relative signal strengths of the radio signals.

One embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings wherein;

FIGURE 1 is a schematic block diagram of a mobile radio telecommunication system;

FIGURE 2 is a schematic illustration of the propagation of radio signals from the mobile stations shown in Figure 1 to one of the base stations shown in Figure 1;

FIGURE 3 is a schematic block diagram of a receiver embodied in one of the base stations shown in Figures 1 and 2;

GR 98 P 2423

8

FIGURE 4 is a schematic block diagram of a further receiver embodied within one of the base stations shown in Figures 1 and 2; and

5 FIGURE 5 is a schematic block diagram of a rake finger.

The example embodiment of the present invention will be illustrated with reference to a mobile radio telecommunications system, and in particular to a mobile
10 radio communications system which operates in accordance with code division multiple access (CDMA). CDMA has been selected by the European Telecommunications Standards Institute (ETSI) as the radio access technique for a third generation mobile telecommunication system known as the Universal Mobile
15 Telecommunications System (UMTS). For a paired band, in frequency division duplex mode, the ETSI UMTS standard is arranged to operate in accordance with a wide band CDMA technique and in an unpaired band, in time division duplex mode, the radio access technique is a Time Division/CDMA
20 multiple access technique. The present invention finds application with both W-CDMA and TD/CDMA technique.

An illustrative example of a mobile radio telecommunication system is illustrated in Figure 1. In Figure 1 a plurality of
25 mobile stations MS, are shown to communicate using radio signals 1, transmitted between the mobile stations MS and a plurality of base stations BS. The base stations BS are disposed in a spaced part relationship so as provide a radio coverage area which may be conceived to be made up from a
30 number of cells 2. A cell 2 is defined as a geographical area within which radio communications may be effected with a base station BS as supposed to any of the other base stations BS in a mobile radio network. In Figure 1 the cells 2, formed for each of the three base stations BS illustrated are
35 defined by the broken line 4. The mobile stations MS communicate data with each of the base stations BS using radio signals 1.

GR 98 P 2423

9

Data is communicated between the base station BS and mobile stations MS by combining the data with a user specific spreading code and then modulating the result onto a radio frequency carrier. A characteristic of CDMA radio access is that mobile stations MS are arranged to communicate radio signals contemporaneously to the base stations BS which operate to recover data symbols communicated by the mobile stations by de-spreading the received radio signals with a user specific spreading code. At the receivers in the respective base and mobile stations, the received radio signals are de-spread, by correlating the radio signals with respect to the user specific spreading sequence to the effect that the data symbols communicated are recovered in spite of the presence of contemporaneously detected CDMA signals from other mobile stations. Each of the mobile stations MS may be considered to be a user of the system, and as such, the term 'user' will be used in the following description to identify signals or data to be communicated from a particular source to a particular sink.

An illustration of the communication of CDMA signals between the mobile stations MS and one of the base stations BS shown in Figure 1 is illustrated in Figure 2 where parts also appearing in Figure 1 bear identical numerical designations. In Figure 2 a plurality of mobile stations are shown to communicate radio signals contemporaneously with the base station BS. A characteristic of the transmission of radio signals within a bandwidth which has been assigned to mobile radio communication systems is that the radio signals reach the receive antenna via a plurality of paths. This is illustrated in Figure 2 by the lines 8, 10, which reach a receive antenna 6 of the base station BS via a direct path 8, and at least one additional path 10, which is reflected via an object such as a building 12. As a result of the multi-path propagation of the radio signals, the data communicated by the radio signals will exhibit inter symbol interference

GR 98 P 2423

10

in a case where a temporal difference in the time taken for the radio signals to reach the receive antenna 6, via at least two paths is greater than a symbol period. As such mobile radio communication systems must be provided with means to mitigate the effect of inter symbol interference.

As illustrated in Figure 2 the base station BS detects the received radio signals via the receive antenna 6 and communicates the detected radio signals to a front-end receiver 14. The front-end receiver 14 operates to down-convert and analogue to digital convert the received radio signals and feed the base band digital samples to a data detector 16 via a conductor 18. The data detector 16, operates to recover and separate the data symbols communicated by the radio signals transmitted by each of the mobile stations contemporaneously and pass the separated detected user data symbols to the mobile radio network for further processing via conductors 20.

An illustrative embodiment of the data recovery means 16 shown in Figure 2 is illustrated in Figure 3, where parts also appearing in Figure 2 bear identical numerical designations. The data recovery means 16 is shown to be comprised of a data store 22 to which the received sampled base band signals are fed via conductor 18. An output of the data store 22, is fed to each of a plurality of data detectors 24. The outputs of each of the data detectors 24, are fed to a signal strength estimator means 26, and further to a data combiner means 28. The output of the data combiner means 28, is presented on a plurality of conductors 20, and corresponds to the recovered data symbols associated with each of the users. Coupled to the signal strength estimator means 26, and the combiner means 28, is a receiver controller 30. The operation of the data recovery means 16 will now be described with reference to CDMA signals.

GR 98 P 2423

11

The received digital samples representative of the detected radio signals are first fed from conductor 18, to the data store 22. These received signal samples correspond to a burst of radio signals of predetermined duration and having a predetermined number of user data symbols. In the following description it is assumed that the receiver has already been provided with means for synchronisation with this predetermined burst of radio signals. The received signal samples are fed to each of the data detectors 24, which in the case of CDMA signals are representative of fingers of a rake receiver. Thus, each of the data detectors 24, is a rake finger and together the data detectors 24, form a rake receiver. Assigned to each of the rake fingers 24, is a user specific spreading sequence and one of a plurality of temporal displacements with respect to an impulse response of a communications channel through which the radio signals have passed.

As is familiar to those skilled in the art, a rake receiver comprises a number of rake fingers, each of which is arranged to correlate the received radio signals against the user specific spreading sequence and to sum the result of the correlation in order determine an estimate of the transmitted data symbol. Furthermore, each of the fingers of the rake is temporarily positioned to the effect of cross-correlating the user specific spreading code at a particular relative temporal position within a channel impulse response which describes the radio communications channel through which the received signals have passed. Thus, in the case of the present example where the radio signals have reached the receive antenna via a plurality of paths, an optimum rake receiver will arrange for the fingers of the rake to correlate at temporal positions corresponding to the respective delays experienced by the radio signals at each of the plurality of paths.

GR 98 P 2423

12

At a first iteration, the plurality of rake fingers are equally assigned to the corresponding numbers of users, to the effect that each user is assigned in the present example three rake fingers. Each of these fingers is temporarily positioned to the effect of recovering energy of the received radio signals at a particular temporal displacement matched to the impulse response of the channel through which the received signals have passed. The rake fingers thereafter generate an estimate of the user data symbols at the output which is fed to the signal strength estimator means 26. The signal strength estimator means 26 serves to provide a measure indicative of the relative strength or confidence in the estimated data symbol for each of the estimated data symbols determined by the corresponding rake fingers. The estimated data symbols and the estimate of the signal strength are thereafter fed to the combiner means 28, which serves to combine each of the estimated data symbols associated with each of the users so that for each user a composite data symbol is generated and output on the conductors 20. However under control of the receiver controller 30 users which are found to have a relatively weak signal strength by the signal strength estimator means 26, may be further estimated by adapting the assignment of the rake fingers 24, to the effect that the users with relatively weak radio signals are assigned more of the rake fingers 24, than users having relatively strong signals. Thus for users which have already been determined to have a relatively strong signal strength the already detected data symbol for these users may be output on the conductors 20. However, for the relatively weak radio signals the receiver controller 30 operates to once again feed the stored burst or radio signals from the data store 22, to the rake fingers 24, and to correspondingly reassign the rake fingers to the effect that more of the rake fingers 24, are arranged to correlate the received radio signal against the user specific sequence corresponding to users with relatively weak signal strengths. Furthermore, in correspondence with the channel impulse

GR 98 P 2423

13

response determined for the user with a relatively weak signal strength, the relative temporal positions of the rake fingers 24, are reassigned, so that the delays of the rake fingers correspond to the paths by which the radio signal from the weak user reached the receiver. As such, the rake fingers are distributed in accordance with the channel impulse response experienced by the radio signals for this user with the effect that each of the rake fingers is assigned to a temporal position corresponding to a relatively significant component of the channel impulse response. With this further iteration the combiner means 28, receives from each of the rake fingers assigned to a particular user an estimate of the data symbol of that user which is therefore combined by the combiner means 28 to form the composite user data symbol which is output on a corresponding one of the conductors 20.

An example of a receiver which would operate in accordance with the data recovery means 16 as described, is provided in the aforementioned published article in the IEEE Transactions on Communications, Vol. 43, No. 2/3/4, February/March/April 1995 at page 1556 by U. Fawer et al. This known data recovery means is an illustration of an iterative data detector for recovering data from CDMA modulated signals in which fingers of the rake are assigned equally to each of the users, and for which corresponding estimates of data symbols are generated. Further iterations of the process are effected in accordance with the signal strength of the received signals to the effect that the data symbols for each user are estimated by cancelling from the received radio signals the effect of the radio signals from the other users. Thus, in the present example embodiment the signal strength estimator 26, and combiner means 28, could be formed by a single processor under control of the receiver controller 30.

A further example embodiment of the present invention is provided in Figure 4 where parts also appearing in Figures 2

GR 98 P 2423

14

and 3 bear identical numerical designations. In Figure 4 a data recovery means 16 corresponds generally to the data recovery means shown in Figure 3. However the data recovery means 16 shown in Figure 4 is further arranged to feed back symbol decisions determined from first iterations of the detection process and to regenerate the effect of the radio signals in accordance with the estimated data, and to subtract the effect of these regenerated signals from the received signals in subsequent iterations of the detection process. In Figure 4 the burst of received radio signals is again fed from the data store 22, to each of the rake fingers designated 24'. Also fed to the input of the rake fingers 24' are regenerated signals fed from a modulator 32 under control of the receiver controller 30. Estimates of the data symbols for each user as formed from the composite signal decisions made by the combining means 28, and are fed via the conductors 20, to the receiver controller 30 by conductors 34. The operation of the data recovery means 16 shown in Figure 4 is substantially in accordance with that shown in Figure 3. However the signal strength estimator means 26 on a first calculation of the estimated data symbols is used to identify the relative strength of the radio signals associated with each user as for the case with the data recovery means 16 shown in Figure 3. However for the data recovery means 16 shown in Figure 4, users with relatively strong radio signals are arranged to be assigned a greater share of the rake fingers 24' to the effect that the data symbol estimates associated with the relatively strong users are estimated and formed by the combiner means 28 and fed to the modulator 32 via the receiver controller 30. Thereafter the modulator means 32 operates to regenerate the radio signals formed by these users which are therefore fed back to the rake fingers 24'.

An illustrative example of such a rake finger 24' is shown in Figure 5 where parts also appearing in Figures 4 bear identical numerical designations. In Figure 5 the regenerated

GR 98 P 2423

15

radio signals are fed via a conductor 36 to a signal subtractor means 38. Also fed from the receiver controller 30, on a conductor 40, is a control signal fed to a data store 42. The control signal fed on conductor 40, serves to
5 select which of the user specific sequences stored in a data store 42, is fed to a correlating filter means 44. In operation therefore in a subsequent iteration of the detection process, regenerated signals fed on conductor 36 are subtracted from the radio signals stored in data store 22
10 as they are fed to the rake fingers 24' by the subtraction means 38. The correlating filter 44 thereafter operates to correlate the subtracted received radio signals against the user specific sequence fed from the data store 42, and to form a symbol decision at the output of the matched filter
15 means 46, representative of an estimate of the communicated data symbol associated with this user. The estimates of the data symbols are thereafter fed from the rake fingers 24' to the combiner means 28 via the signal strength estimator 26. The combiner means then operates to form a composite symbol
20 decision presented on the output conductors 20. Thus, unlike the data recovery means 16 shown in Figure 3 the effect of providing the modulator 32 under control of the receiver controller 30 and means for subtracting regenerated signals from the received signals serves to change the detection
25 process of the data symbols from each user. For the data recovery means 16 shown in Figure 4, in a first iteration, users with relatively strong signals are assigned more of the rake fingers 24' to the effect that a strong estimate of the data symbols for these users is generated which is thereafter
30 used to regenerate the radio signals corresponding to these estimated data symbols. On a subsequent iteration the rake fingers 24' are assigned to the next weakest users and the effect of the already detected user data symbols is subtracted from the received signals to the effect that the
35 rake fingers assigned to the next weakest user signals and distributed amongst the most significant signal components serve to provide a better estimate of the data symbols of the

GR 98 P 2423

16

next weakest users. Thereafter, further iterations of the detection process are introduced with the data symbols from the users already detected being used to form the regenerated radio signals which are subtracted from the radio signals stored in the data store 22 to the effect that the weaker users may be detected using the rake fingers reassigned to them for the subsequent iteration. After all data symbols from all users have been estimated, a further burst of radio signals is fed to the data store 22 and the detection process is reiterated.

As an illustration, the following simple assignment strategy is provided for a total number of fifty available rake fingers for use in detecting data symbols from ten users. For each user the relative signal strength is determined by the signals strength estimation means 26, after the correlating filter effected by the rake fingers 24', for all of the temporal displacements determined from the channel impulse response corresponding to each user. The fifty strongest paths are then selected from the total of all users. The rake fingers are thereafter assigned in accordance with a relative strength of the detected data symbols and this assignment changes from iteration to iteration. Initially users with weak signals are not assigned rake fingers, since there is a possibility that detection of this data before interference cancellation may result in a very low probability of estimating the symbol correctly. For the final few iterations of the detection process, users with weak signals are then assigned a greater number of the rake fingers so as to provide a greater likelihood of detection.

A more advanced strategy, based on the total received wanted carrier signal power to interference power ratio is also possible. For this purpose the interference effect of admitting a specific path must be estimated, including the effect of the correlation factors.

GR 98 P 2423

17

As will be appreciated by those skilled in the art various modifications may be made to the embodiments herein before described without departing from the scope of the present invention. For example, the receiver may be used to detect

5 TD/CDMA signals as well as other forms of CDMA radio access signals. In this case the rake fingers 24, 24', will be replaced by other forms of a data detector such as those disclosed in our co-pending UK patent application No. 9 810 987.9.

10

THIS PAGE BLANK (USPTO)

GR 98 P 2423

EPO - Munich
35

18

28. Aug. 1998

Claims:

1. A receiver for recovering data for at least one of a plurality of users from contemporaneously detected like modulated radio signals generated by said users from user data in combination with a plurality of user specific codes, said receiver comprising:
- a plurality of data detector means (24, 24') each of which is operatively associated with one of the plurality of the user specific codes and one of a plurality temporal displacements with respect to an impulse response of a communications channel through which the radio signals have passed, each of said data detector means (24, 24') operating to estimate symbols of said data for one of said users from said received radio signals in combination with said user specific spreading code and said temporal displacement,
 - a signal strength estimation means (26) which operates to determine a relative strength of the received radio signals from which each of said user data symbols was estimated by said data detectors, and
 - a receiver controller (30) which operates to assign said user codes and said temporal displacements to each of said data detectors (24, 24'), wherein said receiver controller (30) operates to re-assign said plurality of spreading codes and said temporal displacements to said data detectors (24, 24') consequent upon said relative strength of said radio signals, thereby facilitating recovery of data symbols for said at least one user.
2. A receiver as claimed in Claim 1, wherein said receiver controller (30) operates to assign said user specific codes to said plurality of data detectors (24, 24') to the effect that more of said data detectors (24, 24') are assigned the same user specific spreading code and different temporal displacements for a user having a relatively weak signal strength.

GR 98 P 2423

19

3. A receiver as claimed in Claim 1, and further comprising a signal re-generator means (32) coupled to said data detector means (24, 24') which operates to re-generate said received signals associated with at least one user, by combining said estimated user data symbols with said one of said plurality of user specific codes in dependence upon one of said temporal displacements, wherein said data detectors (24, 24') further include means (38) for subtracting said regenerated signals from said received signals, prior to estimation of said user data symbols.

4. A receiver as claimed in any preceding claim and further including a combiner means (28) coupled to said plurality of data detector means (24, 24') and arranged to combine said estimated symbols associated with the same user to form composite symbol decisions to recover the data for the user.

5. A receiver as claimed in Claim 4, wherein said combiner means (28) is a joint detector means which operates to cancel contemporaneously detected data symbols from said composite symbol decision to recover the data associated with one user.

6. A receiver as claimed in any preceding claim, and further including
- a data store (22) which serves to store said radio signals received within a pre-determined time window, which stored radio signals are iteratively fed to said data detectors (24, 24') under control of said receiver controller (30).

7. A receiver as claimed in any preceding claim, wherein the data detector means are rake fingers (24, 24'), the user specific codes being spreading codes, the radio signals from the plurality of users being generated in accordance with code division multiple access.

8. A receiver as claimed in any preceding claim, wherein said signal strength estimator means (26) further operates to

GR 98 P 2423

20

estimate the strength of components of said radio signals received at said temporal displacements, and said receiver controller (30) further operates to re-assign said plurality of data detectors in accordance with said relative strength of said signal components.

9. A method of recovering data for at least one of a plurality of users from contemporaneously detected like modulated radio signals generated from user data and a plurality of user specific codes, said method comprising the steps of;

- processing said radio signals with a plurality of data detector means so as to estimate data symbols associated with a plurality of said users at a plurality of temporal displacements with respect to an impulse response of a communications channel through which said received signals have passed;

- determining a relative strength of the radio signals from which each of said user data symbols were estimated; and

- re-assigning user specific codes and temporal displacements to said plurality of data detectors for at least one of said users in dependence upon the relative signal strengths of said radio signals.

10. A method as claimed in Claim 9, and further including the steps of;

- storing said radio signals received within a pre-determined temporal window; and

- re-estimating said user data symbols for said re-assigned codes and temporal displacements from said stored radio signals, thereby providing an improved estimate of said user data symbols.

11. A method as claimed in Claim 10, and further including the step of

- further re-assigning said user specific codes and said temporal displacements in dependence upon said relative

GR 98 P 2423

21

signals strengths and further re-estimating said user data symbols from said stored received radio signals, further detecting said user data symbols.

- 5 12. A method as claimed in Claim 9, and further including the step of;
- storing said radio signals received within a pre-determined temporal window;
 - re-generating some of said radio signals from said
 - 10 estimated user data symbols and said user specific spreading codes for at least one temporal displacement;
 - subtracting said re-generated radio signals from said stored radio signals;
 - for user data symbols not so far detected, re-assigning to
 - 15 said data detectors the user specific codes of said not so far detected users and a plurality of said temporal displacements; and
 - estimating said not so far detected user data symbols using said data detectors.

- 20 13. A method as claimed in Claim 12, and further including the steps of;
- repeating the steps of regenerating radio signals for said detected user data symbols and subtracting the regenerated
 - 25 radio signals from the stored radio signals;
 - further re-assigning to said data detectors the user specific codes of said not so far detected users and a plurality of said temporal displacements; and
 - further estimating said not so far detected user data
 - 30 symbols.

14. A method as claimed in Claim 13, and further including the step of
- repeating the steps of claim 13 until the data symbols from
 - 35 all users have been detected.

GR 98 P 2423

22

15. A method as claimed in any of claims 10 to 14, and further including the steps of

- determining the relative strengths of components of said received signals at each of said plurality of temporal

5 displacements; and

- assigning said temporal displacements to said plurality of data detectors in dependence upon the relative strength of said signal components.

10 16. A method as claimed in any of Claims 9 to 15, and further including the step of

- combining each of the user data symbols associated with particular users to form composite output symbols.

15 17. A method as claimed in Claim 16, and further including the step of

- joint detecting the effects of the data symbols from other users and cancelling said effects from said composite output signal.

20 18. A method as claimed any of claims 9 to 17, wherein said user specific codes are spreading codes, said radio signals being combined with said data in accordance with code division multiple access.

25 19. A receiver as herein before described with reference to the accompanying drawings.

THIS PAGE BLANK (USPTO)

98e6523
98 P 2423

EPO - Munich
35
28. Aug. 1998

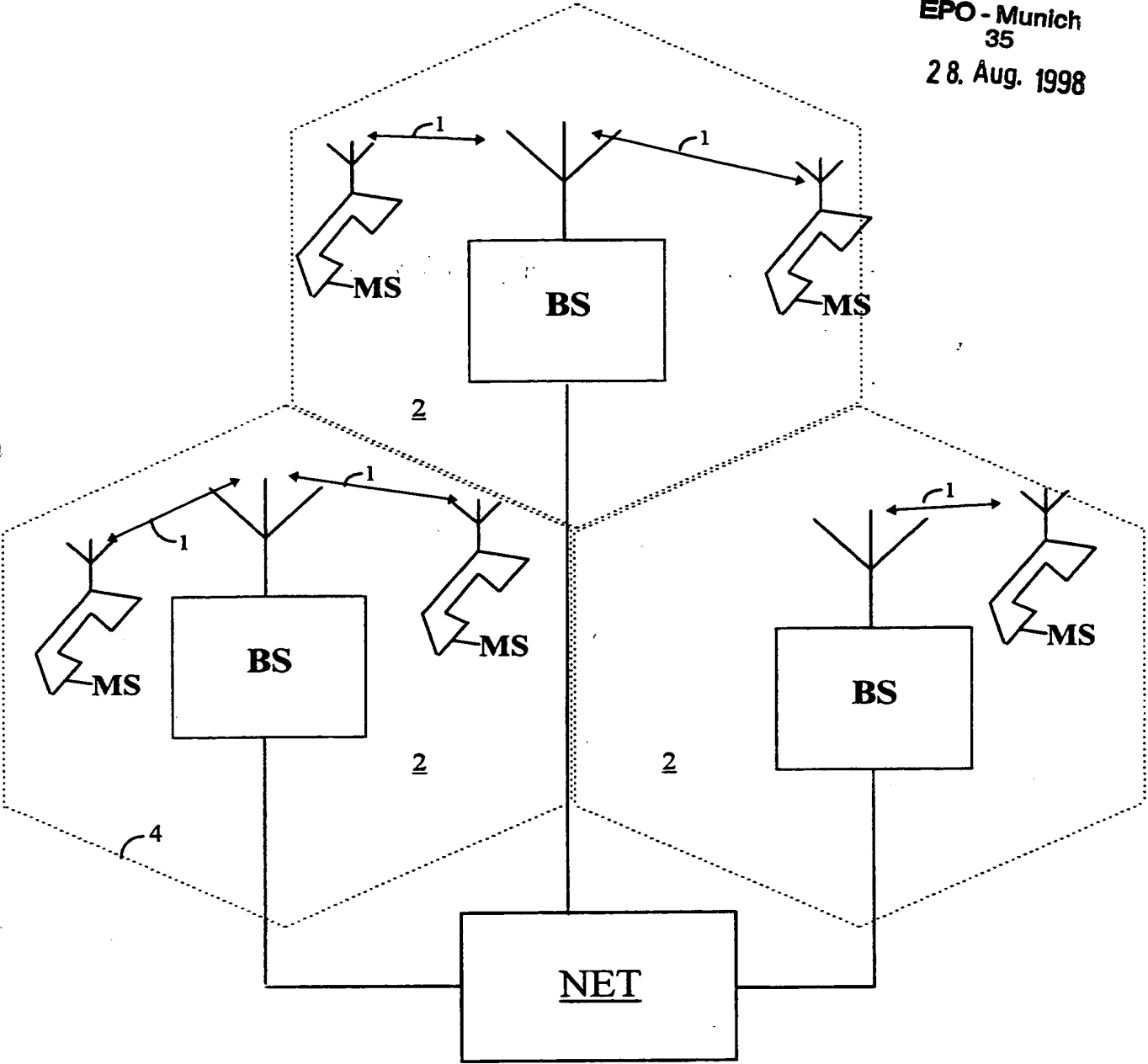


Fig. 1

98e6523
98 P 2423

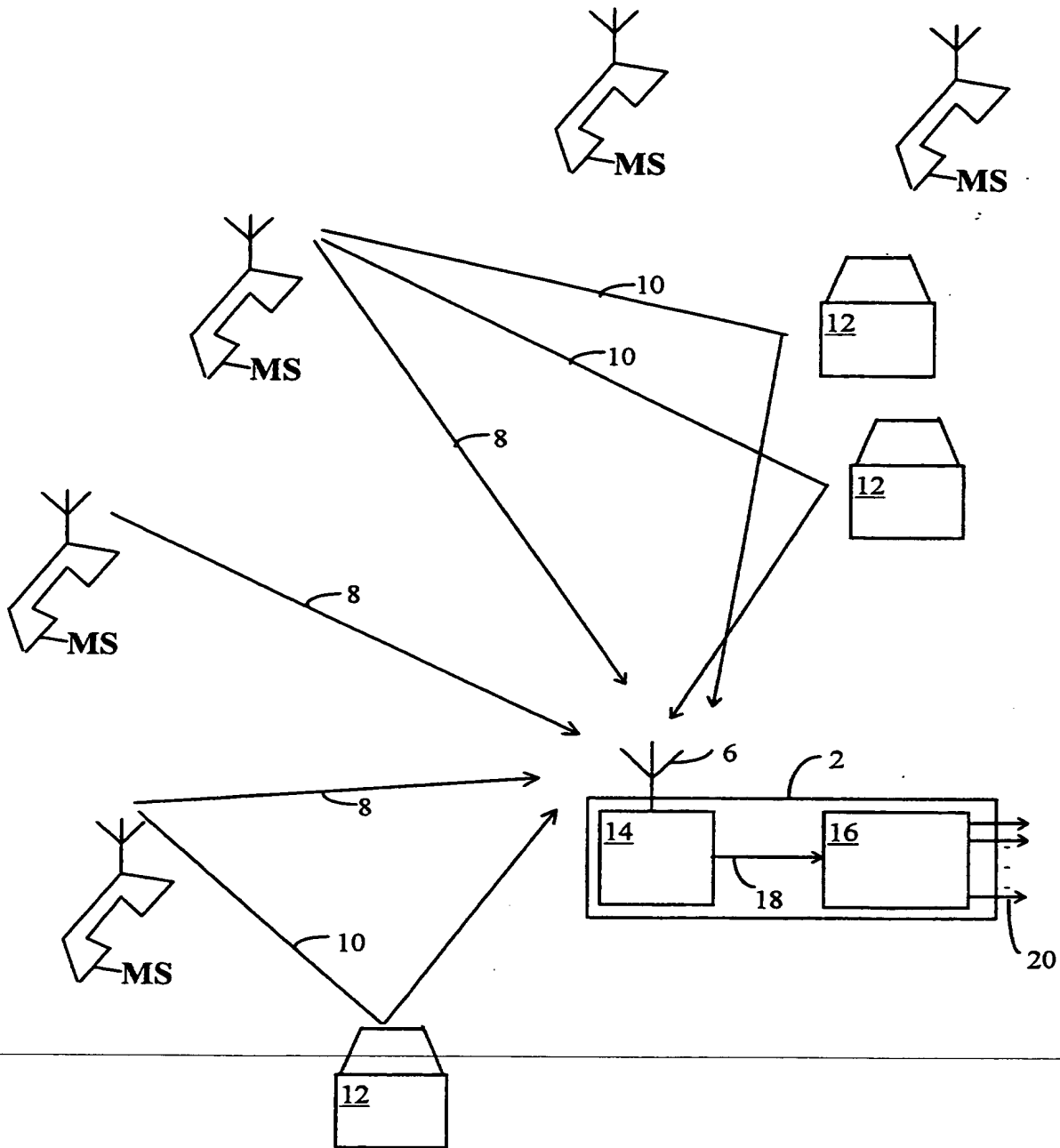


Fig. 2

98e6523
98 P 2423

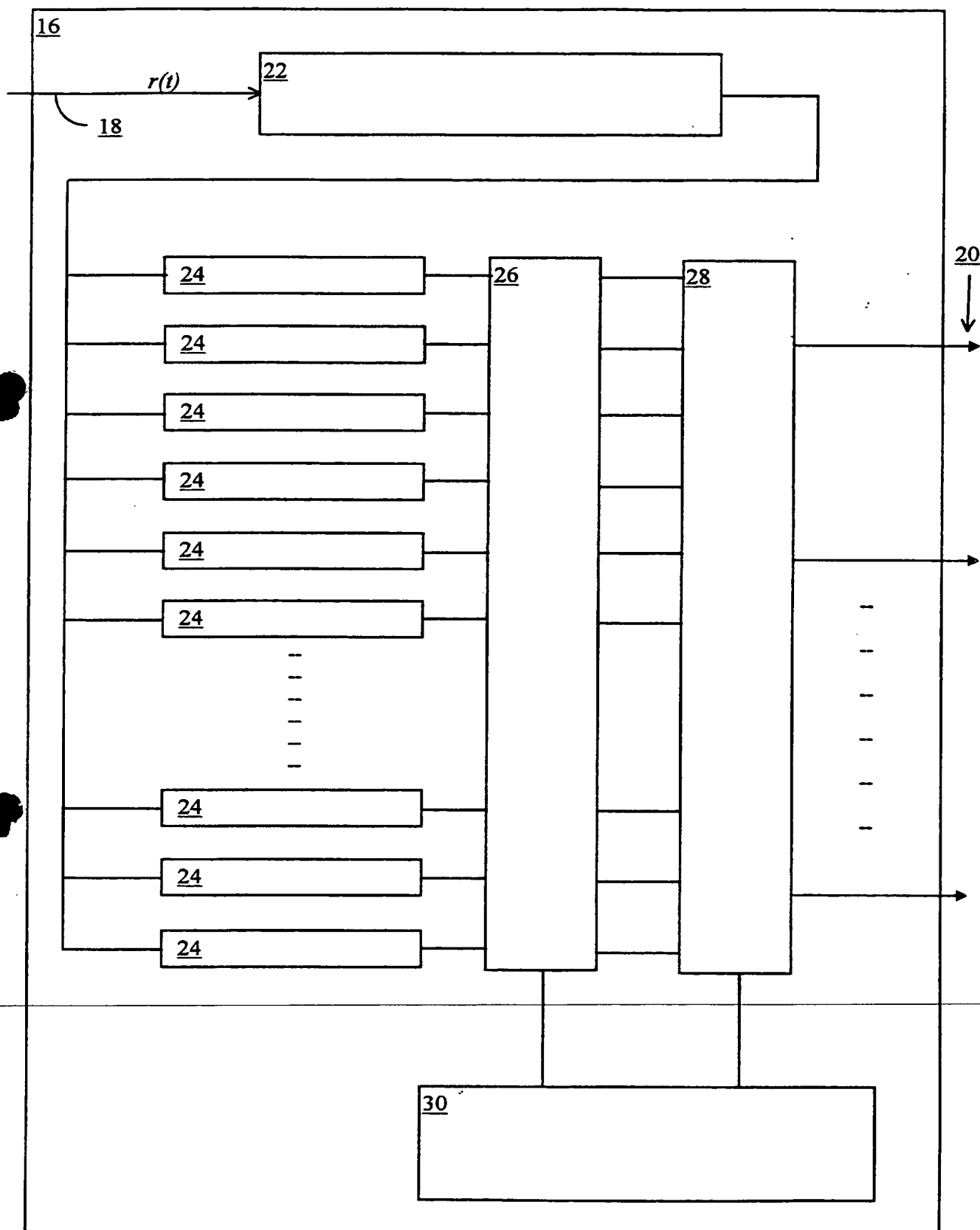
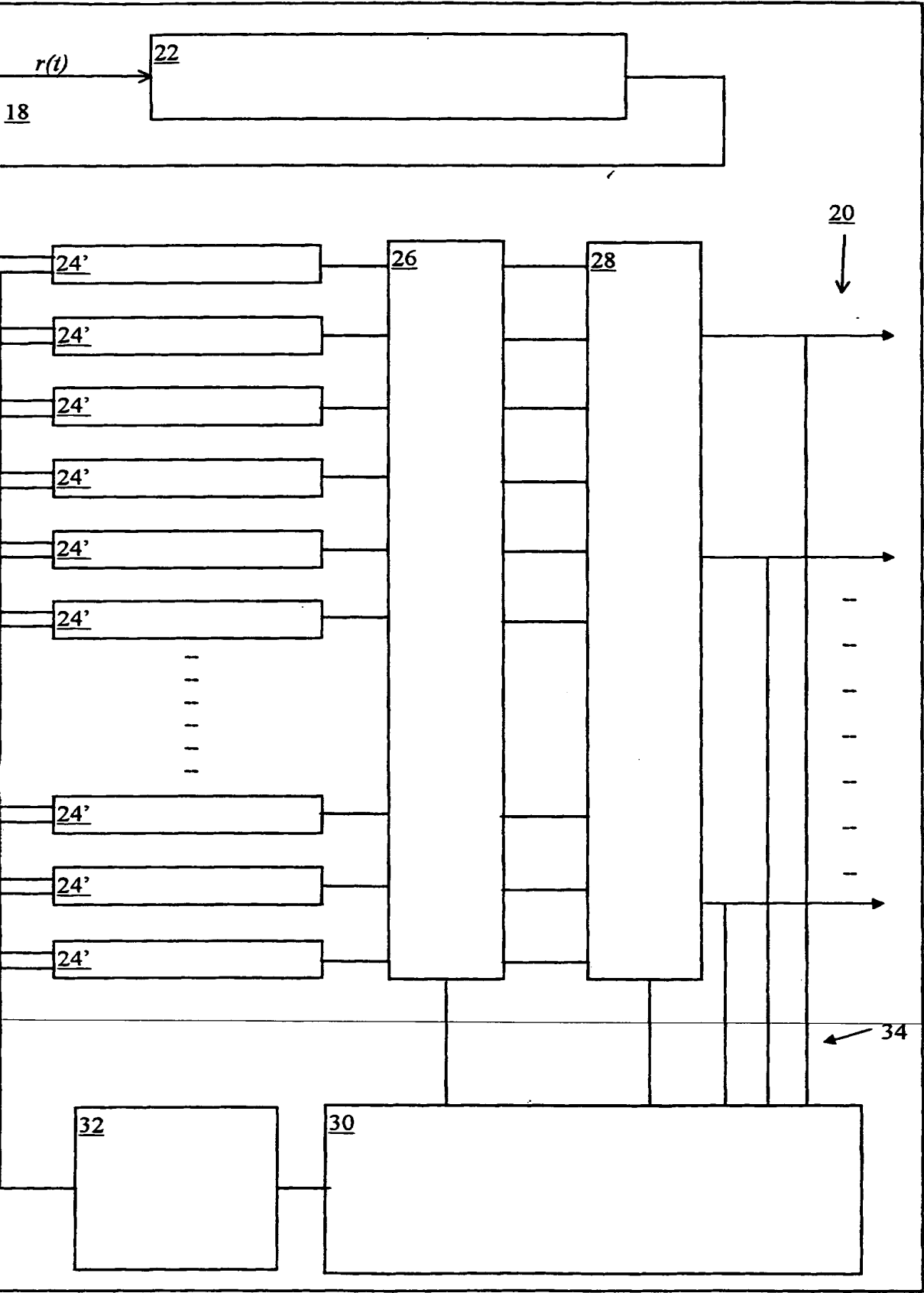


Fig.3

5523
'2423



98e6523
98 P 2423

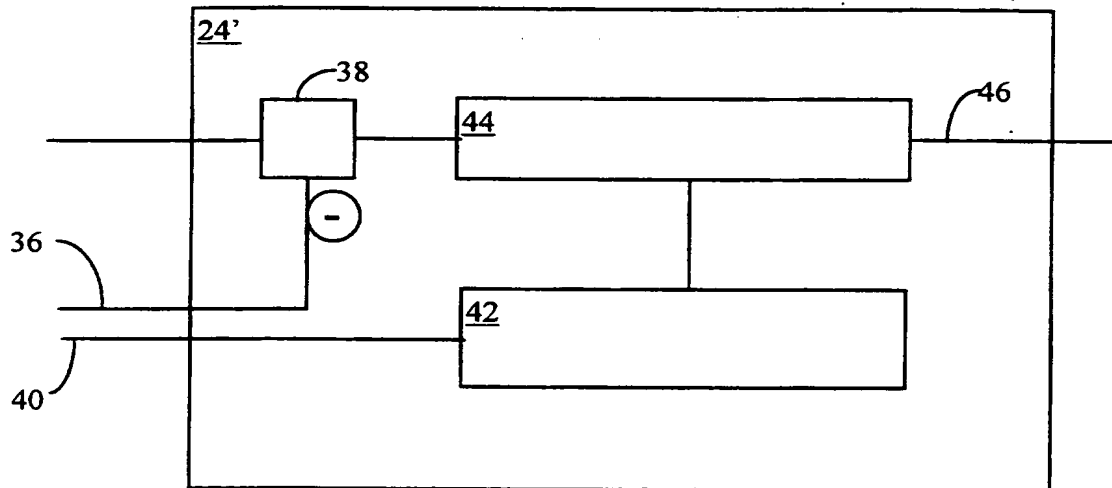


Fig. 5

THIS PAGE BLANK (USPTO)

Abstract

Receiver and method of recovering data from radio signals

5

10

15

20

25

A receiver for recovering data for at least one of a plurality of users comprising, a plurality of data detector means (24, 24') coupled to the data store (22), each of which data detector means (24, 24') is operatively associated with one of a plurality of the user specific codes and one of a plurality temporal displacements with respect to an impulse response of a communications channel through which the radio signals have passed, each of the data detector means (24, 24') operating to estimate symbols of the data for one of the users from the received radio signals in combination with the user specific spreading code and the temporal displacement, a signal strength estimation means (26) which operates to determine a relative strength of the received radio signals from which each of the user data symbols was estimated by the data detectors, and a receiver controller (30) which operates to assign the user codes and the temporal displacements to each of the data detectors (24, 24'), wherein the receiver controller (30) operates to re-assign the plurality of spreading codes and the temporal displacements to said data detectors (24, 24') consequent upon the relative strength of the radio signals, thereby facilitating recovery of data symbols for the at least one user.

THIS PAGE BLANK (USPTO)